

THERMAL ANALYSIS OF FINS WITH MODIFIED TIPS

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ABSTRACT

Fins, the topic of this analysis, is an extended surface which is used as a source of increasing the rate of heat transfer for beneficial aspects. This is a steady state analysis. The edge of the fins is configured with various types like rounded tip, wedge shape and flat end. Mostly fins are used to transfer heat from the object to the atmosphere. Hence convective heat transfer analysis is carried out on the three different fins with different ends. The fins are designed as in an automobile radiator and hence two materials; copper and aluminum are used for all the three design configurations. From the results, the better configuration will be evident.

KEYWORDS: Design CATIA V5, Rectangular fin, Rounded tip, Wedge shaped & ANSYS Thermal analysis

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INTRODUCTION

Fins are used to increase the rate of heat transfer from an object to the surrounding or to the surrounding to the object. However, in most phenomenon fins are being used for the transfer of heat from object to the atmosphere for the purpose of cooling. The heat transfer between the body and the atmosphere can be increased by increasing the temperature difference between the surface and the fluid, then by increasing the fluid flow over the extended surface and by increasing the contact area of the extended surface. Now, apart from these general ideas of increasing convection, in this project a slight different ideology has been adopted. The ends of the fins has been given a different edges and is analyzed for heat transfer gradient. The models in this analysis are made with CATIA V5 and the analysis is carried out with Ansys Workbench.

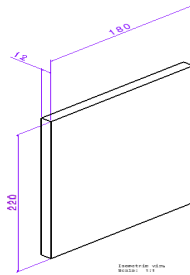
METHODOLOGY

The first primary step is to design the three different models for the analysis. The models are designed with the help of CATIA V5. The next step is to gather all the boundary conditions for the heat analysis that is done with ANSYS workbench. Also, The analysis includes two kinds of materials for each type of design made. For the designs, we include copper and aluminum to all three models and check the most efficient amongst the three.

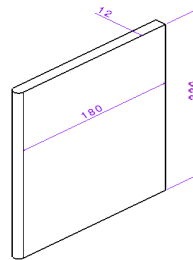
Step 1: Design of the Fin

As denoted earlier, increased heat transfer can be attained in two forms with respect to the design of the fins. Hence, the surface area of the has been increased under certain assumptions and the dimensions used are fin thicknesses: 0.004 in (0.1 mm) to 0.012 in (0.3 mm), heights: 0.035 in (0.89 mm) to 0.6 in (15.24 mm), and densities: 8 to 30 FPI (Fins Per Inch).[Considerations from an automobile radiator]. The individual fin design are given below,

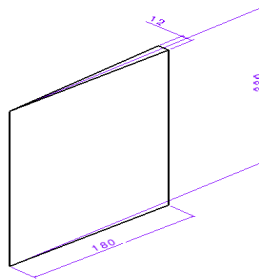
Rectangular Fin



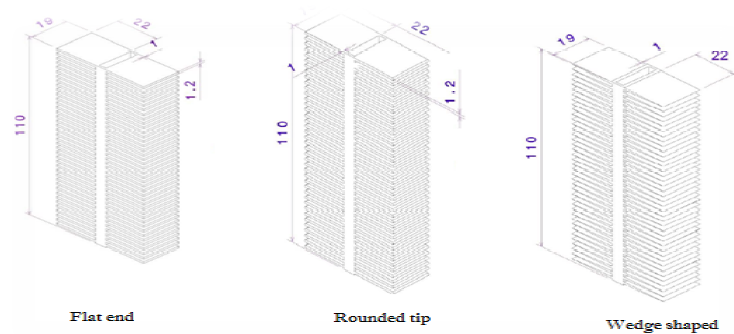
Rounded Tip



Wedge Shaped



Full Structure of an Automobile Radiator with Individuals Designs of all Three Modifications



Step 2: Thermal Analysis

Thermal analysis is carried out with the help of Ansys workbench. The reason behind to choose two different materials for each design is because, with one single material, the characteristics of the design cannot be assured and also since, the design is based on an automobile radiator, these two materials are chosen. Hence, two different, materials are selected and each design is analyzed, with the properties of both the materials. The properties of Copper and Aluminum are given below:

PROPERTIES OF COPPER

- Copper possesses very high electrical conductivity
- It also has very high thermal conductivity
- It exhibits excellent resistance to corrosion
- It is very soft, ductile and malleable
- It becomes brittle just below its melting point
- It can be worked in hot or cold condition, but it cannot be welded

Properties	values	units
Density	8933	Kg/m ³
Thermal conductivity	398	w/m.k
Coefficient of thermal expansion	10	w/m ² K
Specific heat (cp)	385	J/kg/k
Ambient temperature	25	°C
Base temperature	100	°C

PROPERTIES OF ALUMINIUM

- It posses good electrical conductivity.
- It also has very high thermal conductivity
- It exhibits excellent resistance to corrosion
- It is very soft, ductile and malleable
- It becomes brittle just below its melting point

Properties	Values	Units
Density	2700	Kg/m ³
Thermal conductivity	236	w/m.k
Coefficient of thermal expansion	10	w/m ² K
Specific heat (cp)	900	J/kg/k
Ambient temperature	25	°C
Base temperature	100	°C

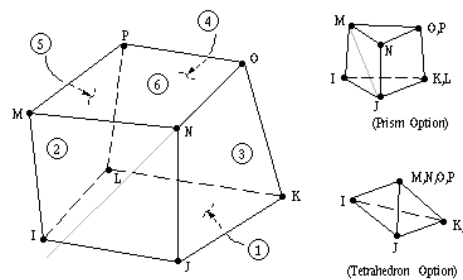
Comparison of Few of the Properties of Copper and Aluminum

CHARACTERISTICS	COPPER	ALUMINUM
Tensile strength (lb/in ²)	50,000	32,000
Tensile strength for same conductivity (lb.)	50,000	50,000
Weight for same conductivity (lb.)	100	54
Cross section for same conductivity	100	156
Specific resistance (ohms-cir/mil ft) (20°C ref)	10.6	18.52
Coefficient of expansion (per deg. C x 10 ⁻⁶)	16.6	23

Once the material properties are defined the next step in analysis is the finite element analysis, the element type chosen is hexahedral thermal solid and its properties are given below:

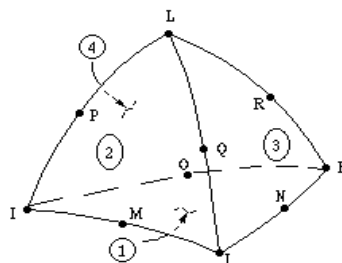
8-Node Hexahedral Thermal Solid (SOLID70)

SOLID70 has a three-dimensional thermal conduction capability. The element has eight nodes with a single degree of freedom, temperature, at each node. The element is applicable to a three-dimensional, steady-state or transient thermal analysis. The element also can compensate for mass transport heat flow from a constant velocity field. If the model containing the conducting solid element is also to be analyzed structurally, the element should be replaced by an equivalent structural element.



10-Node Tetrahedral Thermal Solid (Solid87)

The element has one degree of freedom, temperature, at each node. The element is applicable to a three-dimensional, steady-state or transient thermal analysis.



Once the meshing is done, the boundary conditions are applied. The boundary conditions applied are given below.

PARAMETERS	VALUES	VALUES
MODE TYPE	FORCED CONVECTION	FORCED CONVECTION
MATERIAL TYPE	COPPER	ALUMINIUM
VOLUME	$2.4482e^{-005} \text{ m}^3$	$2.4482e^{-005} \text{ m}^3$
MASS	0.2187 kg	6.5833e-002 kg
ANALYSE TYPE	3D	3D
NODES	96886	96886
ELEMENTS	45329	45329
BOUNDARY CONDITION	500w/m ²	600w/m ²
CONVECTION	22 ^o C, 20 w/m ² .c	22 ^o C, 20 w/m ² .c
HEAT FLOW	500W	500W

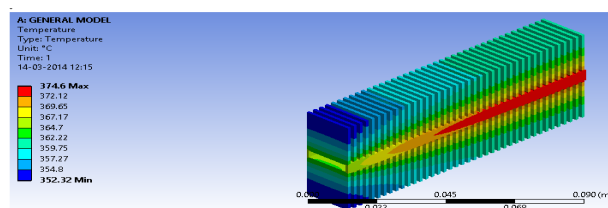
Property	Copper(Cu-ETP)	Aluminium(1350)	Units
Electrical conductivity (annealed)	101	61	%IACS
Electrical resistivity (annealed)	1.72	2.83	mOhm-cm
Thermal conductivity at 20°C	397	230	W/mK
Coefficient of expansion	17×10^{-6}	23×10^{-6}	/°C
Tensile strength (annealed)	200-250	50-60	N/mm ²
Tensile strength (half-hard)	260-300	85-100	N/mm ²
0.2% proof strength (annealed)	50-55	20-30	N/mm ²
0.2% proof strength (half-hard)	170-200	60-65	N/mm ²
Elastic modulus	116-130	70	N/mm ²
Fatigue Strength (annealed)	62	35	N/mm ²
Fatigue Strength (half hard)	117	50	N/mm ²
Specific heat	385	900	J/kgK
Density	8.91	2.70	g/cm ³
Melting Point	1083	660	°C

The analysis has been carried out and the results have been analyzed and shown below. Looking at the results, it is clearly seen that the wedge design with copper properties have better heat transfer than the other two.

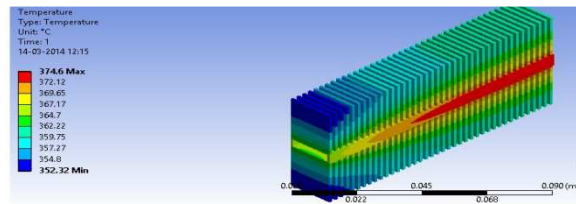
RESULTS FOR EACH MODE OF DESIGN

Flat Tip

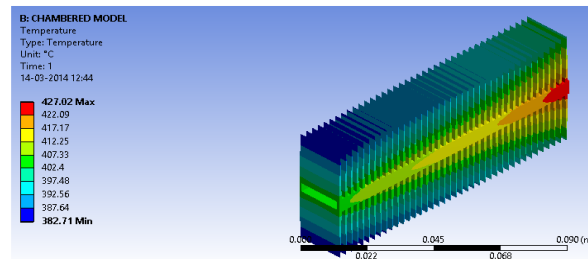
Aluminum



Rounded Edge

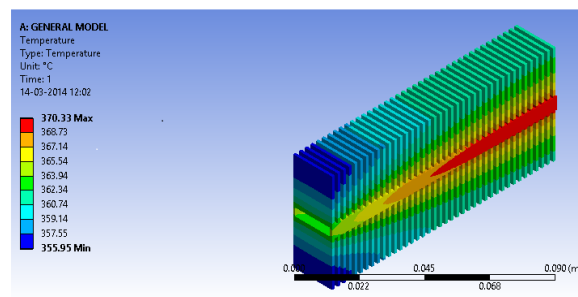


Wedge Shaped Tips

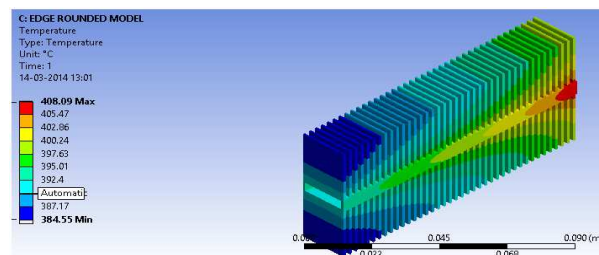


II Copper

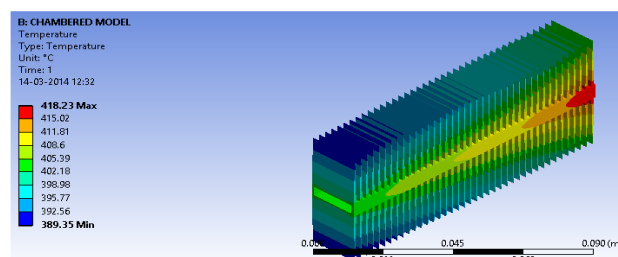
Flat End



Rounded Tips



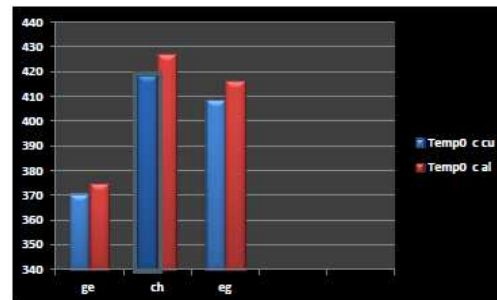
Wedge Shaped Tips



The results are computed and tabulated below:

MODEL	ALUMINIUM W/m ²	COPPER W/m ²
GENERAL(1)	374	370
EDGE ROUNDED(2)	427	418
CAMFER(3)	415	408

Bar Chart for the Above Comparison



THEORETICAL CALCULATION

Convective Heat transfer,

$$Q = (t_b - t_\infty) h p k A$$

T_b base temperature (K)

t_∞ surrounding temperature

h Heat transfer coefficient (W/m²K)

p (Perimeter)

k Thermal conductivity (W/mK)

A area (m²)

Q_{CON} of copper = 1253 W/m²

Q_{CON} of aluminum = 1023 W/m²

CONVECTIVE HEAT TRANSFER

MODE OF CALCULATION	COPPER	ALUMINIUM
THEORETICAL	1253 W/m ²	1023 W/m ²
BY ANSYS	1173 W/m ²	9436 W/m ²

CONCLUSIONS

The models are analyzed and from that are observed that, the normal rectangular fin takes much time for the dissipation of heat, however, in case of the wedge and rounded configuration, the heat transfer happens quicker. From the theoretical and results from the analysis, it is evident that, the wedge shaped configuration is more efficient than that of the other two. Also, the copper being better heat resistant along with wedge shape will prove to have better heat transfer than the other types.

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